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Intelligent Fish feeding through Integration of ENabling technologies and Circular principle

Grant Agreement (GA) No: 818036

D5.3 Comprehensive Analysis about the Business Enablers 2nd Version

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Reviewer		ABT Coordination, NORCE				
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Disclaimer

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Executive Summary

This deliverable D5.3 (Comprehensive analysis about the Business Enablers 2nd Version) aims to conduct the analysis on the identification of the different business enablers of the iFishIENCi project, who will facilitate the implementation of KERs throughout the project. Consequently, business enablers will also contribute indirectly to the future post-project activities and achievements. The different actions carried out by the selected business enablers will be aligned with the exploitation route and intellectual property protection strategy of the iFishIENCi project. In this second and last version of the deliverable (M52), results on a stakeholders' survey and the gathering of other primary sources were analysed to complete the analysis carried out on this report.

This document will follow support the development of the key exploitable results and D5.6 (Exploitation strategy). On this deliverable, a complete list of selected business enablers has been produced, as well as a detailed analysis on the competitive advantage for each one of the main KERs ("products").

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Abbreviations

KER	Key Exploitable Result
MCDA	Multi-Criteria Decision Analysis
SIE	Sustainable Innovations Europe
KER	Key Exploitable Result
ERIC	Eliminate, Reduce, Increase, Create
FCR	Feed Conversion Ratio

1 Introduction

This deliverable (D5.3) is the second version of the ***Comprehensive Analysis about the Business Enablers*** customized for the iFishIENCi project, funded by the European Union under the Grant Agreement (GA) No. 818036. The first version (D5.2) aimed to apply the overall structure and the methodologies described in D5.1, attending to the identification of main project's business enablers and the exploitation of future results of the project. This second version aims to extend the identification and detail of the business enablers and the exploitation of future results of the project, following the methodological roadmap, including primary information from surveys.

To analyse and describe the main targeted groups of business enablers, this version contains the current and future barriers and challenges identified per each *Product* to be developed and exploited within iFishIENCi (i-BOSS, Fish-Talk-To-Me, Waste2Value, Smart RAS), as well as the competitive landscape ("battlefield to compete") along the value chain of operations. The impacts to each one of the products to circularity have also been summarized, supported by previous market analysis (D5.4). The findings of the first version of the deliverable (D5.2) were the base to design individual circular-based business models in D5.5, and in this second version the updated findings will support the final version of the Exploitation/Strategy and customer and Market Approach (D5.6), as well as the stakeholder engagement activities that will be directed to these business enablers and with the support of WP6.

The partners in the iFishIENCi project must, in accordance with the article 28.1 in GA, take necessary measures to ensure the exploitation of the project results up to 4 years after the end of the project. The report of Comprehensive Analysis about the Business Enablers intends to cover a high-detailed analysis of the value chain at industry scale, what are the different competitive advantages of each KER and what are the different actors involved: *implementors* (iFishIENCi consortium) and *facilitators/enablers* (those identified on this deliverable). The deliverable results will be generated during the project lifetime and will mainly depend on the outcomes resulting from the exploitation plan and IPR management practices. Those elements are interconnected to each other to assure the possibility of success of the exploitation after the project lifetime.

2 Product Management

To carry out to objectives of the Comprehensive Analysis and aiming to outline the methodology described above from more concrete approaches, the main Key Exploitable Results of the iFishIENCi project, selected as the ones with most potential to enter the market for commercialization ("products") have been prioritized.

The analysis on these KERs from a business perspective ("product-approach") will bring a light on a preliminary identification of potentials business enablers throughout the value chain of activities, main product barriers before market entry and competitive positioning to be adopted. Consequently, a product-market fit will be defined for each KER considering selected target markets in the final version of the Exploitation Strategy (D5.6).

At M24, a product management strategy was defined to conduct the first analysis on business enablers. For each of the iFishIENCi products, a product manager related to the KER development was assigned to provide continuous feedback on KERs development and assist the exploitation management committee in its future product-market fit strategy.

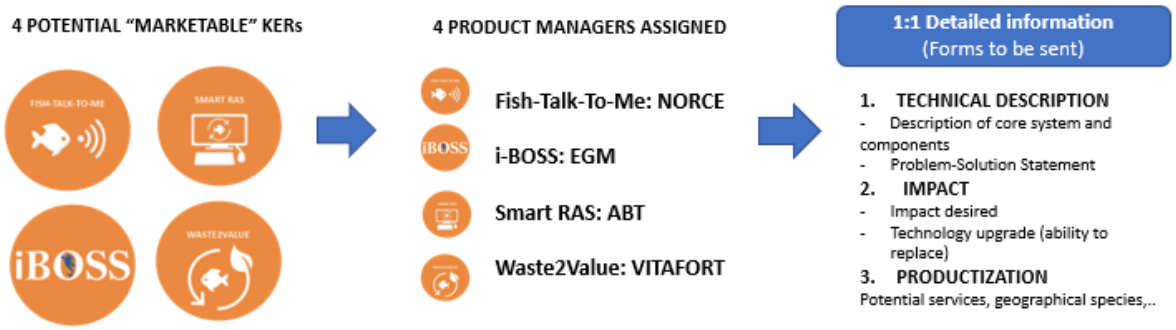


Figure 1. Methodology for Productization of main Key Exploitable Results.

From M24, next exploitation activities and discussions have been oriented to the "productization" of the above-mentioned KERs. As first results on the strategy implementation, four different forms on each one of the iFishIENCi products have been filed with key aspects for its commercialization, such as a list of current and potential competitors, or current state of experiments and product development phase. An example of the Product Management Sheet can be found in the Annex: Product Management Sheet (M30).

The list of the product-based key aspects is described below:

Table 1. Example of Product Management Sheet's overview

Product Phase	Value Chain phase	Description
Section 1: "Throughout the project".	**TECHNICAL DESCRIPTION**	**Key Exploitable Result (KER) description**. *Please include principal characteristics/functions/how it works, etc.*
	IMPACT	**Contribution to development by partners and ownership**. *Please indicate the contribution of each partner and how the ownership will be distributed among the partners.* **Current State of Experiments**. *Please indicate the current stage of experiments to estimate time-to-market (2-3 years after project end).* **Contribution to proposed impacts.** *How will this new technology/product (KER) contribute to increase sustainability?*
Section 2: "Going to the Market".	**PRODUCTIZATION**	**Value Proposition**. *What makes this new technology/product (KER) attractive to the potential markets/users? Key benefits or problems solved by this new technology/product? What it does better than existing technologies/products?* **Pros and Cons**. *What is the strength/advantage and weakness/disadvantage of this new technology/product (KER) comparing to existing technologies/products?* **Benefits for potential target customers and way to market**. *Who is the target customers or users and how to sell it?* **Potential Competitors**. *What technology/product/company do you think will be the major competitors for this KER?* Future commercial applications. *What are the different applications for this new technology/product (KER)?* Target geographical markets. *What are the target markets (in terms of continents and countries) you plan to enter and commercialize your technology/product?*

The results provided from the product-based approaches will be the basis for the comprehensive analysis of this deliverable (D5.3). However, a survey directed to the first identification of business enablers (Section 3) has been designed to gather primary research on the current landscape on

stakeholder and customer adoption of Aquaculture 4.0 technologies (general market of iFishIENCi products). The survey can be found in the Annex: "Stakeholders' survey" and was be refined by iFishIENCi partners before launch producing a briefer survey in order to be better received by respondents, this shorter version can be found in Annex: "Brief Stakeholders' survey". The launching date of the shorter survey was November 2022, to gather the necessary inputs to analyse results by M52 (D5.3 Comprehensive Analysis of Business Enablers version 2).

Internally, Product Workshops led by Product Managers were held from M24 to M36, to set up a post-project strategy and guarantee stakeholder engagement. Project Advisory Board members were invited and contributed to each one of the workshops. The outcomes of these workshops served to perform a broader analysis on the individual business model for each product.

3 Identification of business enablers

Business enablers have been identified and redefined according to the survey findings, considering the iFishIENCi products' main customer segments and attending to the competitive landscape of each of them, the latter has also been updated.

One of the main key drivers for a successful market entry for any of the products lies on the **degree of technology adoption by the different customer segments**. However, the decision on adopting new aquaculture approaches within currently existing business models becomes complex, especially for fish farmers focused in geographical areas where technology does not drive market positioning.

Therefore, it will be discussed more in detail within the next exploitation plan the need for iFishIENCi products to approach traditional players with the identified emergent inclusive business models (D5.7), incentivizing partnerships between technology providers and traditional players, by means of leasing agreements. These practices are expecting to establish a strong link between cutting edge technologies integrating AI and IoT and small and medium-size farming companies and their barriers. (Hoffman & Koniken, 2017).

3.1 Inclusive and Sustainable Business models

In this deliverable (D5.3) the identified emergent business models are presented and therefore associated with the iFishIENCi business enablers in order to shape an accurate customer and business approach. In order to introduce the emergent inclusive business models it is necessary to be clear about the traditional business models set out below.

3.1.1 Traditional Business Approach

Before analysing recently introduced trends and potential business strategies, investors and stakeholders should understand conventional aquaculture business models and current approaches to value creation, to evaluate the disruptive and innovative aspects for the aquaculture production systems coming. Traditionally, business models followed within aquaculture producers can take a two-level approach: *vertical integration* and *product diversification*.

3.1.1.1 Vertical Integration

A major type of management and organization recently adopted by most aquaculture economies for corporate operations in developing countries. The management of the industry (large/industrial scale, medium size and/or small) starts from the selection and acquisition of the site, followed by the production of seeds, the rearing in the grow-out, the preparation of feeds, post-harvest processing and marketing of the fish crop.

However, vertical integration can also take many forms according to the level of ownership and operational capability of producers. Traditionally, three main categories of producers can be distinguished: **fully integrated producers** who usually are governed by large holding groups, maintain exclusive control of production assets, critical inputs, and downstream value-added activities. This sub model is often common in global mature markets such as in the salmon sector, and recently adopted regionally in the case of bivalve production. Farming remains as the main core business driver, accounting for 65.75% of revenues. On the opposite, **grow-out ("Pure Play") producers** are usually family-owned, small businesses operating within less mature markets, which mainly serve from vertical integration to enrol in cooperative agreement so they can achieve modest economies of scale. They do not have the operational capability to make upstream or downstream investments and tend to be a very fragmented segment. Gaining production capacity by means of long-term agreements or joint ventures, they could become **semi-integrated producers**, owning exclusivity in certain production assets (in-house hatchery, primary processing, bloodstock operations, basic cold-chain logistics or key supply components.). (M.Joffre & Dickson, 2017).

3.1.1.2 Product diversification

Any producer independently from the level of integration, may diversify or not its production according to product categories. In most cases, diversifying the product portfolio within aquaculture is not easy: technical barriers such as the need of specific skillsets for managing very distinct species across diverse environments and cold-chain requirements and geographical ones regarding distribution assets, marketing efforts or relationships. In aquaculture, producers tend to be undiversified, mostly falling into a single product/species or diversify falling into a specific product category or production method for further specialization and positioning in that sector (FAO, Committee On Fisheries: Aquaculture Innovations, Their Upscaling and Technology Transfer to Increase Efficiency Combar Environmental Degradation and Adapt to Climate Change. , 2019). It does not necessarily depend in production scale or level of integration. In Europe, large salmon producers have may diversify their portfolio growing other salmonids such as rainbow trout or the Artic chard, only dedicating a small fraction of production share to other species. In China, where marine-pond-aquaculture is considered one of the most potential markets for production, a higher degree of polyculture is found nowadays (e.g. shrimps and other fish species in a single system).

3.1.1.3 Inclusive business models

As in any other industry, traditional business approaches have also been adapted during the past of time and according to the rising demands of more local, sustainable business practices that can also imply a major business impact within underdeveloped aquaculture economies and small-scale fisheries. Therefore, inclusive business models (IBMs) have risen, mostly driven by inclusive objectives of the United Nations Sustainable Development Goals, also aiming to adapt the role of private businesses in value chains and development. (Cotula & Vermeulen, 2010).

The concept of inclusive business models is not extensive in the literature, and most it is found within current local practices and reviewed in key articles. The following models are mostly driven by production and supply objectives by collective groups or farmers, but also disclose development objectives set by governmental authorities or non-government organizations (NGOs). (Vorley & Lundy, 2017).

- **Buyer-driven models**: Production from smallholders is driven by off-takers such as processors, retailers, or exporters to maximize benefits in retailing and processing. This is made through securing better contracts and agreement with producers, driven by market demand.

- *Contract farming*: pre-agreed Supply and Purchase Agreements between buyers and farmers (agreed delivery date and price), which usually provides benefits to wholesalers, processors and retailers, while farmers are provided access to markets and more efficient, improved inputs.
- *Joint Venturing (JV)*: a business venture co-owned by two independent market actors, sharing equity, rewards, and financial risks. The market actors usually involved investment funds or venture capitalists.
- *Micro-franchising*: replicating a successful agribusiness model, enabling the franchisee (small-scale fishery, entrepreneur) the expansion to new market entrants to capitalise on existing knowledge, processes, brands and products, while allowing the franchisor (a major firm/corporation) to expand.

- ***Producer*-driven models:** the production is driven by small groups of producers or individuals. They have the objective to establish themselves in new markets, set a strong market positioning, achieve better market prices, supply larger volumes, or increase bargaining power.
- *Tenant farming sharecropping*: Individual farmers can arrange management contracts with larger agribusiness farmers, where smallholders work the land by means of fixing a rental fee. In given cases, the smallholders share the crop with the large business.
- *Farm*-owned businesses: often cooperatives, are organized groups of individual farmers to generate collective action to set market prices, increase bargaining power or share risks towards a specific product. It is also a mechanism to facilitate business transactions.

- ***Intermediary*-driven models**. Models usually led by market actors such as NGOs, wholesalers, and governments to improve quality standards, boosting innovation, increase competitiveness of the industry.
- *Certifications:* providing food production and marketing standards, it facilitates supplier upgrading and more active involvement of government bodies.
- *Public Private Partnerships (PPAs):* partnerships and government arrangements where public institutions and other private bodies engage in order to distribute allocation of risks and resources within the industry, in a decision-making process setting and reaching common consensus and goals.

3.1.2 Potential sustainable business models

Currently, the traditional business landscape within the aquaculture ecosystem should still be considered as a starting point for establishment within a certain geographical market or product. However, in recent years many aquacultures 4.0 innovations have emerged, presenting beneficial options and solutions to existing aquaculture business challenges (feed waste, high power bills, fish behaviour and health, oxygen levels, water and weather events…) (Asia Pacific Food Industry, 2020). On this context, one of the underlying challenges to be considered is the level of adoption of the given technologies, which can also vary according to the geographics, the level of integration, product diversification and ultimately, the aquaculture segment.

Therefore, both public authorities and environmental organizations such as the Nature Conservancy have recently put efforts on increasing the level of awareness towards the adoption of Precision aquaculture tech, also aiming to incentivize private investment actors. Cooperation between both public and private funding schemes can eventually make such technologies affordable and available to all customer segments, boosting global growth within the industry. In the light of successfully introduce cutting-edge technologies in all aspects within the aquaculture supply chain, there are several emerging business strategies which have been identified, considered to be potentially applied within the iFishIENCi innovations.

3.1.2.1 Strategic partnerships between technology providers and traditional players

At point of entry, aquaculture technology requires efficient and tight relationships between tech providers and traditional aquaculture segments (farmers, cooperatives, facility providers, retailing and end customers). Nowadays, most solution providers can be electronics manufacturers and start-ups, who may require building strategic partnerships with key producers and distributors in order to generate trust in end customers. For instance, a joint partnership between a fully vertically integrated producer and a technology provider could suppose a win-win strategy, as the producer can diminish the risk of integrating technology by having full control of operations, while the technology provider can reach key potential clients, and raise awareness on the technology within the general public.

Linked to technology providers, an important player to consider would be connectivity providers. This way, IoT and AI-integrated solutions could also partner mobile operators and connect over mobile data network in a cost-effective manner. In case of offshore aquaculture operations where mobile connectivity is not feasible, satellite communication providers could also get in the game as it becomes more affordable economically.

3.1.2.2 Leasing agreements as a new business model for small and medium-size farm economies

As previously stated, one of the raising concerns of the Precision Aquaculture market lies on the affordability of the technology, which is strictly related to the level of adoption. In some emergent markets such as the Asia-Pacific, which currently produces 86% of aquaculture production output by value, most customer segments are medium and small-size fisheries and farms, who usually confront high financial barriers to adopt and integrate cutting-edge technology to their in-house production systems. On this context, there are several cases arising from technology providers and innovators providing leasing services to businesses interested in adoption, in exchange of a monthly fee. This affordable leasing options may also serve as a way to integrate transparency, better accountability and traceability in the farm operations, thus providing clients a higher visibility at both country and global scale. The more knowledge on the outcomes of the service provided, the higher chances of gaining acceptance and familiarity among risk-adverse investors.

Additionally, these «smart» farms are benefitted from the integrated characteristics of innovative aquaculture systems (feed optimization, reduction of waste, highly-efficient fish and environment control) while technology providers obtain real world-data feedback on the system performance, eventually improving them.

3.1.2.3 Integration of renewable energy systems

In Asia, it is not new the integration of aquaculture with other farming operations, such as the case of freshwater fish reared in flooded rice cultivation fields, in order to maximize farmers' revenue from existing land and area. Tongwei Group, a China-based large aquaculture company, has recently demonstrated the feasibility of integrating solar energy to existing aquaculture farming, through the installation of solar panels and wind turbines over ponds. Consequently, farms are connected to the electricity grid and can benefit from the power surplus generated, providing them extra revenue and additionally establishing a more decentralised power grid, as the population grows and standards of living are more affected by food and energy supply. (Waite & Philips (WorldFish) & Brummett (World Bank), 2014).

Advances in satellite and mapping technology, open data, or ecological modelling are believed to be the future for global-level monitoring and planning systems, which can encourage sustainable aquaculture development.

3.2 iFishIENCi Main Business Enablers

The main factors having a significant impact on technology adoption in traditional farm players have been summarized in previous studies before (Kumar, 2018). Degree of technology adoption will mainly depend on the technology characteristics, economic factors (profitability, input and output prices, availability of capital, labour availability), farm characteristics (farm size, ownership, and tenure), and sociodemographic and institutional factors of the geographical scope of the customer segment. In the next exploitation plan, these factors will be described in more detail considering the target market identification and analysis.

The main business enablers identified for the iFishIENCi products are:

- **Individual Farmers**. End users having already a high degree of technology adoption to act as early adopters of the product during market entry. According to the figure displayed in D5.7, it is important to emphasize on the farm type characteristics and point out who the early adopters of iFishIENCi technologies will be. More specifically:
  - Industrial Aquaculture Companies.
  - Medium-Small scale Commercial Aquaculture Companies.
- **Technology Developers**. Being an important player in the phase of commercialization and spreading awareness on the product at market entry phase. They act as intermediaries facilitating integration of the technology within end users' in-house operations. They may become a crucial part in the adoption of inclusive business models in the case of having to agree with end users the use of a software license, or the use of a specific product for an agreed time (leasing).
- **Feeding companies**. Having Waste2Value as one of the Key Exploitable Results, the revalorization of by-products for production of feed ingredients is one of the key results aimed within the scope of iFishIENCi. Therefore, feeding companies revalorizing waste and selling and developing sustainable aquafeed become a key player enabling the productization of

iFishIENCi KERs. It also becomes a key element for the project adoption of circular business models.

- **Investors and Policymakers**. Policymakers have significant impact on aquaculture regulations and the need of a friendly institutional frameworks to facilitate the establishment of aquaculture innovations in growing aquaculture markets. Investors have also been considered a growing player spreading awareness to the public about the future business opportunities that the sector offers, offering alternative funding schemes for aquaculture innovators.

These four players are considered business enablers for the iFishIENCi products,

Figure 2. Main iFishIENCi Business Enablers

3.2.1 Business Enablers Primary Information Analysis.

Primary information sources as the conducted survey allowed the identification of the level of engagement of the business enablers on current aquaculture technologies, and their willingness to implement these technologies in projects or in-house operations. The survey gathered information of the stakeholders from 15 different countries in Europe, Asia, South America and Africa (n=26). Results show that 92.30% of the stakeholders are willing to adopt aquaculture technologies, this is a clear sign that the identified groups can be defined as business enablers of the iFishIENCi products. Figure 3 shows the stakeholders experience and willingness to adopt aquaculture technologies, it displays that 80.77% of the stakeholders have implemented some type of aquaculture technology, and from that share, only a 3.85% will not be willing to implement it again. The survey showed that 19.23% of the stakeholders indicated that they had never implemented any aquaculture technology and from this group only 3.85% showed no interest in its implementation.

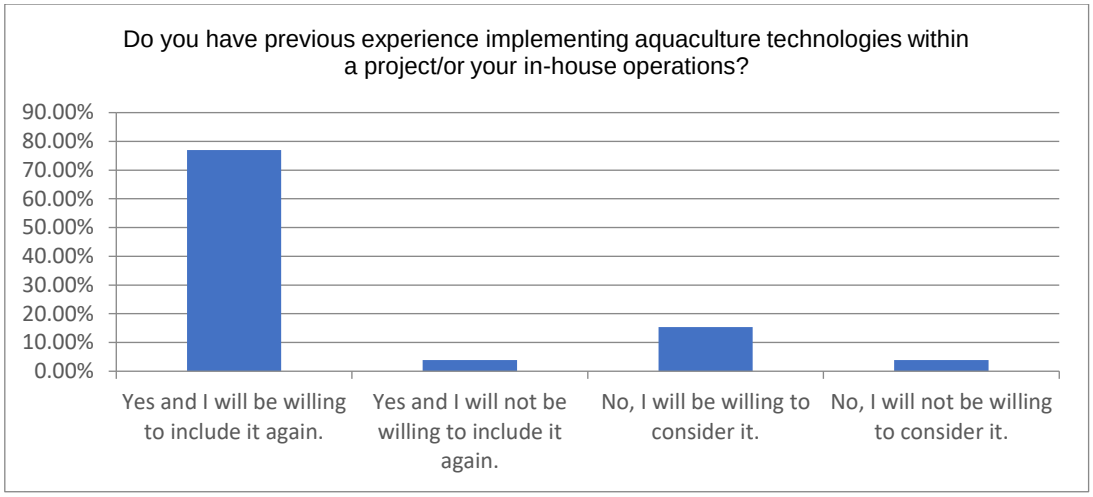


Figure 3. Stakeholders experience and willingness to adopt aquaculture technologies.

From the whole sample, even though most of the stakeholders are willing to adopt aquaculture technologies, it was possible to identify that some groups have not yet implemented any type of aquaculture technology- 50% of the surveyed Aquaculture farmers, Government bodies, Investment institutions, and Marine Protected Areas (MPAs) had never implemented or supported any aquaculture technology. The groups with the lower implementation rates should be addressed with more strong strategies in order to achieve better implementation results.On the other hand, the approach for the stakeholders with higher implementation results should consider a detailed demonstration of the competitive advantages and value added of the project results.The top implementation groups include aquafeed manufacturers, consulting firms, NGOs and system vendors, with 100% of the each group already implementing some aquaculture technology,. Other groups, such as aquaculture farmers and research institutions, have an implementation rate of 87.5% and 75% respectively. Figure 4 shows the stakeholders aquaculture technologies adoption rates.

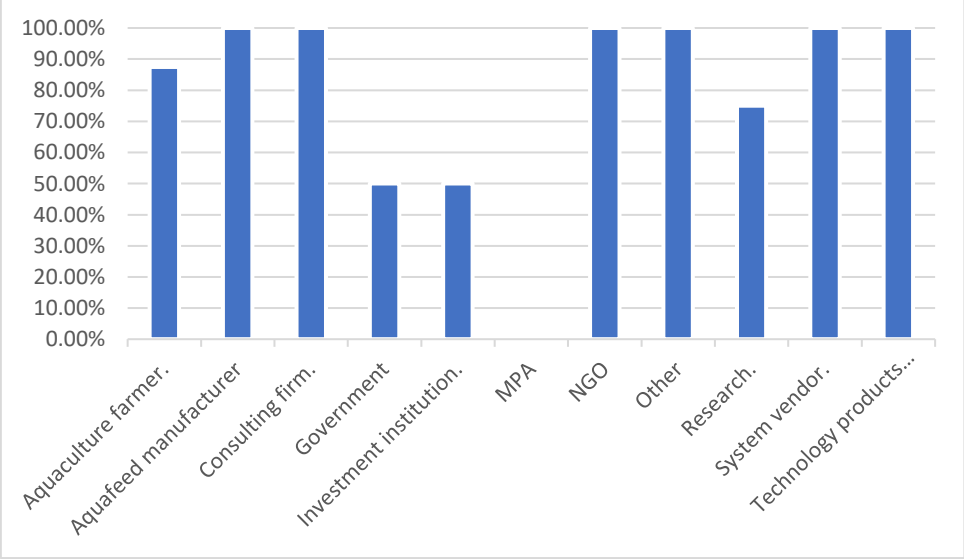


Figure 4. Stakeholders aquaculture technology adoption rate.

3.2.1.1 Business Enablers Primary Information Analysis (Adoption Main Barriers).

In order to define the characteristics of the business enablers and all the stakeholders, the main barriers to adopting new technologies were assessed. Figure 5 introduces the results of the survey on the main 8 barriers.

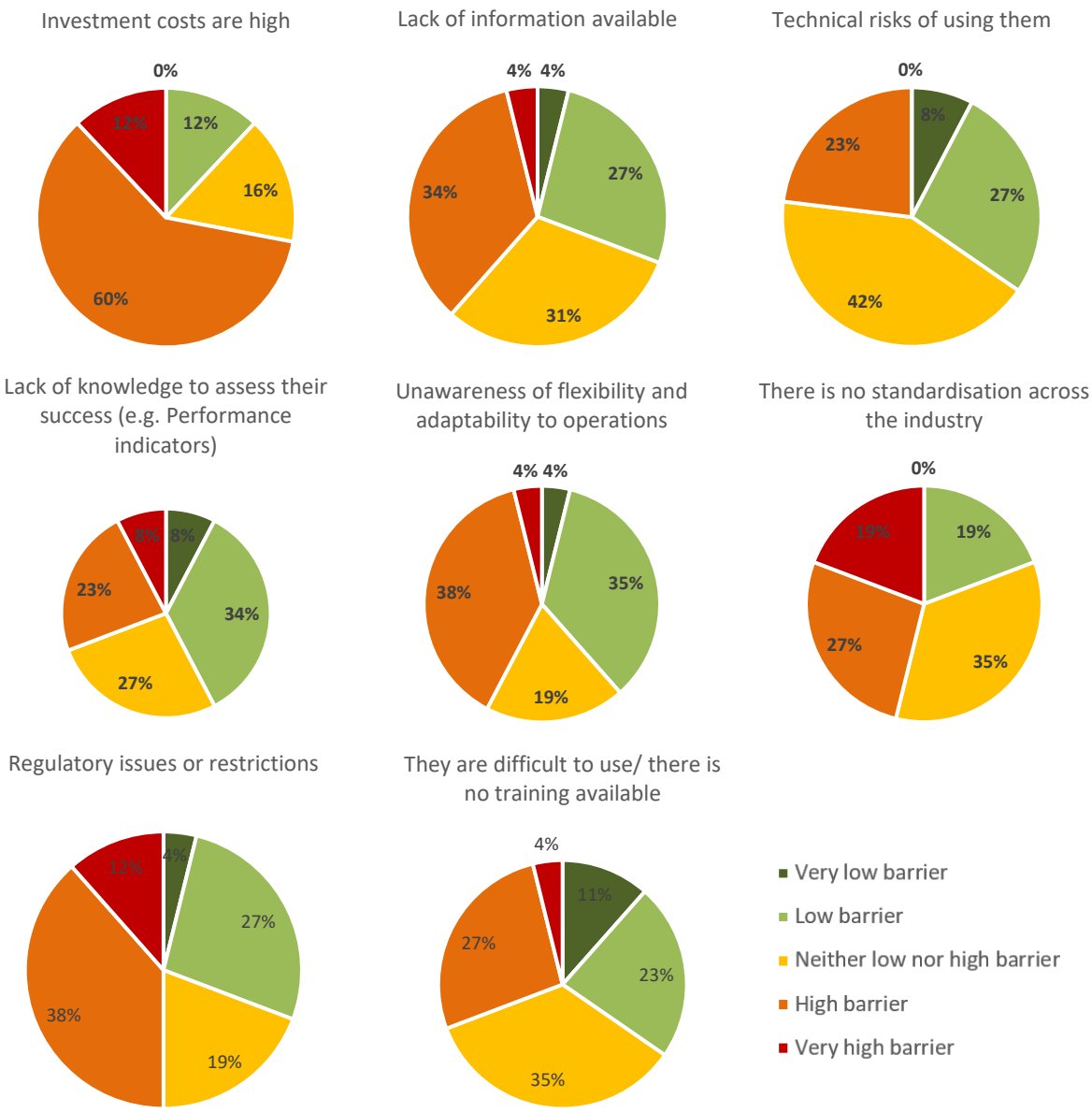


Figure 5. Main barriers for the adoption of aquaculture technologies.

According to the results, the perception that the costs of investment are high is recognised as a high barrier by the 60% of the respondents and as a very high barrier by the 12%. This represents 72% of the overall perception as a barrier, it is quite clear that the implementation of aquaculture technologies is constrained by the perception of being a high-cost investment, so efforts to stimulate the adoption of these technologies should therefore be focused at obtaining high quality, cost-competitive products and advertising these products and services. Regarding the identified business enablers (Farmers, feeding companies, technology providers and policy makers and investors), 50% of

the surveyed aquaculture farmers indicated that high investment costs are a high barrier and 25% believe it is a very high barrier and 100% of the aquafeed manufacturers and government bodies find the high investment costs as a high barrier for the implementation. On the other hand, 100% of system vendors found this barrier as low.

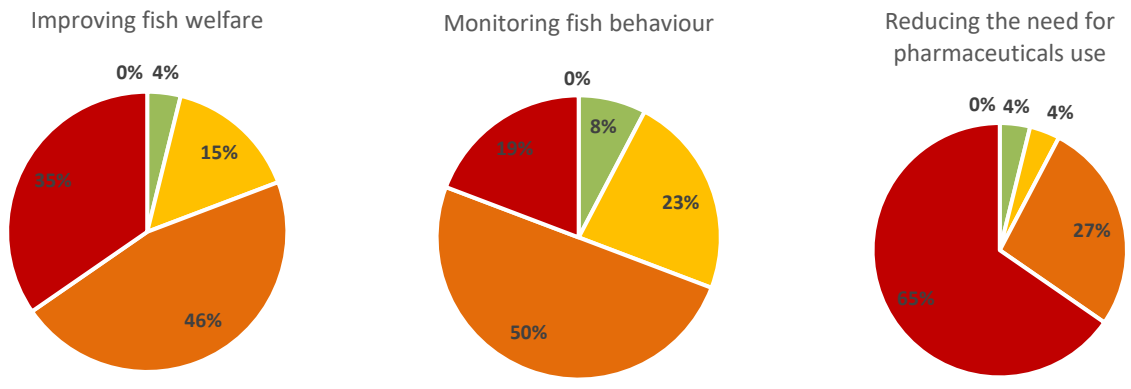
Lack of available information is recognized as a high barrier for almost 35% of the respondents, and from this share, 100% of the system vendors and technology products manufacturers identified this aspect as a high barrier, in contrast 50% of the aquaculture farmers and government bodies identified this barrier as low, and 50% of the investment institutions found this barrier as very low. Regarding the perception of technical risks, most of the respondents answered that this barrier is neither low nor high (42%) and the lack of knowledge to assess the aquaculture technologies was identified as a low barrier by 34% of the respondents being the biggest portion of this barrier.

The unawareness of flexibility and adaptability to operations was found by 38% of the respondents as a high barrier, from this share it is important to highlight that 50% of the aquaculture farmers recognized this issue as a high barrier and therefore the efforts in order to increase the adoption of aquaculture technologies must be addressed to demonstrate the flexibility and adaptability of the proposed solutions for the farmers, as well as for aquafeed manufacturers and system vendors, of which 100% identified this as a major barrier. It was clear that the unawareness of flexibility and adaptability to operations is not fully related with the perception that they are difficult to use or that there is no available training, this aspect was recognised as a high barrier only by 27% of the respondents and more than 34% agree that it is a low or very low barrier.

Regulatory issues or restrictions and standardisation across the industry were identified as the higher barriers after the perception of high investment costs, the former was recognised by 38% of the surveyed stakeholders as high and very high by 12%, and the second by 27% of the respondents as high and by 19% as very high, being this last share (Very high barrier) the higher of all the sample. Regarding regulatory issues or restrictions, 100% of government bodies found this aspect as a high barrier, 50% and 25% of the research institutions found this issue as a high barrier and very high barrier respectively and on the other hand, 50% of the aquaculture farmers believe that this aspect represents a low barrier. Finally, concerning standardisation across the industry, as previously mentioned, 19% of respondent found this aspect as very high being this percentage the higher of all the sample, 100% of key stakeholders such as aquafeed manufacturers, technology products manufacturer and/or vendors and NGOs agree with this classification.

3.2.1.2 Business Enablers Primary Information Analysis (Challenges to be solved).

Continuing with the definition of the characteristics of the business enablers and all the stakeholders, and in order to identify the needs and aspirations of these stakeholders regarding the aquaculture technologies the main aquaculture challenges to be solved by the technology providers were assessed. Figure 6 introduces the results of the survey on the main 8 prioritised challenges to be solved.



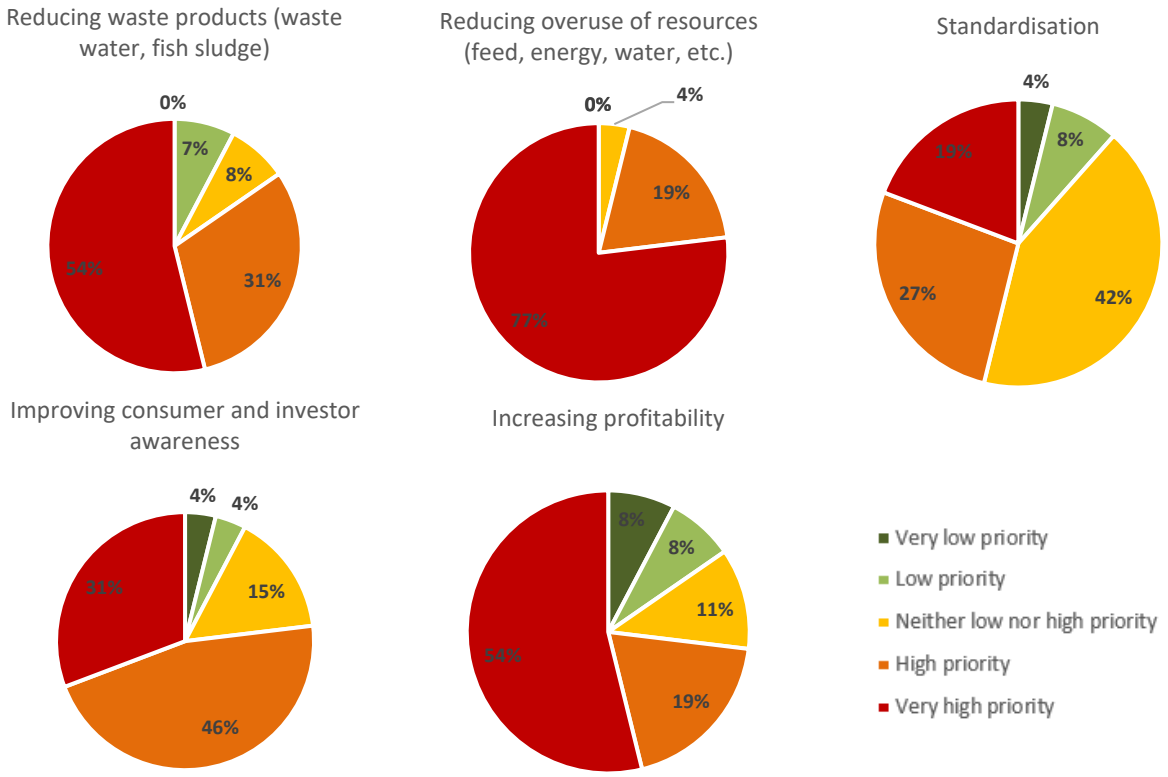


Figure 6. Prioritised aquaculture challenges to be solved.

It is necessary to emphasise the high importance of reducing the overuse of resources (feed, energy, water, etc.) for the business enablers and in general for all the stakeholders, according to the results of the survey this challenge was identified as a very high priority by 77% of all stakeholders, 87.5% of aquaculture farmers, 50% of government bodies and research institutions, and 100% of aquafeed manufacturers, consulting firms, investment institutions, MPAs and system vendors agree with this classification. At the same time, 50% of the technology products manufacturers and vendors consider this challenge to be a high priority to be solved.

After the need of reducing the overuse of resources, the reduction of the need of pharmaceuticals use was identified as the second most important challenge to be solved by the technology providers, this aspect was found as very priority by 65% of the respondents, from this share, 62.50% of the aquaculture farmers, 100% of the aquafeed manufacturers, government bodies, investment institutions, MPAs, and system vendors agree with this very high priority as well as 62.5% of the aquaculture farmers. Additionally, 50% of research institutions and 100% of NGOs and technology products manufacturer and/or vendor consider this challenge as a high priority.

The reduction of waste products was also recognised as a very high priority for the stakeholders, in this case 54% of the stakeholders agree with this classification including 37.50% of aquaculture farmers, 50% of consulting firms, research and investment institutions and 100% of aquafeed manufacturers, government bodies, MPAs and system vendors. Moreover, 100% of NGOs and technology products manufacturer and/or vendors found this aspect of high importance.

Increasing profitability, as in all business, is of great importance for the identified business enablers and in general for all the stakeholders, this aspect was identified as a very high priority for 54% of the respondents, in this case this score was given by 62.50% of aquaculture farmers, 75% of consulting firms, 25% of research institutions and 100 % of aquafeed manufacturers, government bodies and investment institutions. On the other hand, 100% of MPAs found this issue as a very low priority and 100% of technology products manufacturer and/or vendor as a low priority.

Improving fish welfare was also determined as very high and high priority by 81% of the sample, in this case 100% of technology products manufacturer and/or vendor and 50% of consulting firms, investment institutions and research institutions identified this challenge as a very high priority and in parallel, 62.50% of aquaculture farmers and 100% of MPAs found this aspect as a high priority. Finally, other challenges to be solved by technology providers such as monitoring fish behaviour, standardisation, and improving consumer and investor awareness were classified as very high priority and high priority by 19% and 50%, 19%% and 27% and 31% and 46% of the respondents respectively.

The main goal of the identification of the characteristics of the business enablers and all the stakeholders is to be able to increase the adoption rate of the aquaculture technologies through diverse marketing roadmaps and strategies to be defined in the last version of the exploitation plan (Exploitation/Strategy Plan and Customer and Market approach 2nd Version – M55), in this document each of the barriers, needs and aspirations of key business enabler and stakeholders should be addressed according to information provided in this survey, segregated for each iFishIENCi main product and Key Exploitable Result.

3.2.2 Business Enablers and inclusive and sustainable business models integration

As previously mentioned, the identified emergent business models are related with the iFishIENCi business enablers in order to shape an accurate customer and business approach, Table 2 lists the main business enablers and their relations with the emergent business models.

Table 2. Business enablers and emergent business models.

Business Enablers	Emergent Business Models
Individual Farmers	• **Buyer-driven models:** Addressed to the small and mid-size producers (Those with a lower degree of technology adoption and higher barriers to become early adopters of the iFishIENCi products). The pre-agreed Supply and Purchase Agreements between buyers and farmers can maximize benefits for individual farmers, boost access to markets and increase the possibility to become adopters of new aquaculture technologies. • **Producer-driven models:** Addressed to the small and mid-size producers. management contracts with larger agribusiness farmers (Rental fee) and the proper operation of well-structured cooperatives can help producers to set a strong market positioning, achieve better market prices, supply larger volumes, or increase bargaining power. • **Strategic Partnerships:** Strategic partnerships with key producers and distributors in order to generate trust in end customers. Joint partnerships between producers and technology provider could suppose a win-win strategy, for the producers the benefits are related to the reduction of the risk of integrating technology by having full control of operations.

	• **Leasing agreements:** Technology developers providing leasing services to businesses interested in adoption, in exchange of a monthly fee. This leasing service can overcome the high financial barriers to adopt and integrate cutting-edge technology to their in-house production. • **Integration of renewable energy systems:** With the integration of a decentralised renewable energy, farms with hight solar radiation levels can benefit from lower electricity prices and those that are connected to the electricity grid and can benefit from the power surplus generated, providing them extra revenue and additionally establishing a more decentralised power grid.
Technology Developers	• **Strategic partnerships:** Strategic partnerships with key producers and distributors in order to generate trust in end customers. Joint partnerships between producers and technology provider could suppose a win-win strategy, the technology developers can reach key potential clients, and raise awareness on the technology within the general public. • **Leasing agreements:** Technology developers as intermediaries facilitating integration of the technology within end users' in-house operations, can provide leasing services to businesses interested in adoption, in exchange of a monthly fee. This can help especially the new developers by securing a current income that will allow them to have a stable financial performance. • **Integration of renewable energy systems:** Technology developers can take advantage of the integration of renewable energy systems by adapting the solutions to the operation of renewable technologies, increasing even the performance of those solutions.
Feeding Companies	• **Strategic partnerships:** Strategic partnerships with key producers and distributors in order to generate trust in end customers. Joint partnerships between producers, technology providers and feeding companies could suppose a win-win strategy, for the feeding companies the benefits are related to the reduction of the risk of integrating technology by having full control of operations and having the possibility to interact as bridge between the producers (acting as clients and raw materials providers) and the technology providers. • **Leasing agreements:** Technology developers can provide leasing services to businesses interested in adoption, in exchange of a monthly fee. This can help especially the feeding companies to encourage producers to adopt circular technology solutions and take advantage of obtaining economic benefits for both.
Investors and Policy Makers	• **Intermediary-driven models:** Investors and Policy Makers are clear market actors, they can improve quality standards, boost innovation and increase competitiveness of the industry. Both can support the adoption and development of technologies thought: - Certifications. - Public Private Partnerships

In order to increase scope of adoption of new aquaculture technologies from all the business enablers, integration of two or more emerging business models comes up as an attractive scenario, leasing agreements can go hand-by-hand with the integration of renewable energies, providing on the one hand, a platform for the technology developers to introduce their products and, on the other hand,

giving the producers diversified energy sources while benefiting of the new technologies advantages. Strategic partnerships can be combined with producer-driven models, increasing the market scope and impact.

3.2.3 Business enablers per iFishIENCi product

As a result of the product-based approach overview, it was also possible to gather more in detail the specific main customer segments and business enablers for the four iFishIENCi products. A classification according to their relevance through the value chain process has been made below (Table 3):

Table 3. Business enablers per iFishIENCi product

Product	Business Enablers approach
Fish-Talk-To-Me	The service can be **sold as cloud-based service where you can upload data for analysis and interpretation**. Potential vendors: • Feeding companies. • Tech developers and equipment vendors (hardware, software). • Fish health companies. • Individual farmers.
i-BOSS	The market aims to reach anyone delivering **feeding management services and equipment**. The end-customer would be buying from their **technology provider,** and the product will be delivered as an integrated system. Additionally, new companies could also potentially be able to integrate iBOSS with existing sensorics and doing some appetite management. Potential end customers: • Fish farmers • Tech developers • Investors.
Smart RAS	According to the development phase: ○ **Experimental Smart RAS**: Feed producers, Vaccine producers, private and public research institutes, universities, public authorities. ○ **Commercial Smart RAS**: Salmon smolt, land-based salmon, high value niche market fish (barramundi, turbot, large trout etc.) farmers and financial investors worldwide.
Waste2Value	Targeted business enablers include end users such as **algae growers producing algae for aquaculture, animal nutrition and cosmetics**, New feeds (algae & yeast), IMTA/Aquaponics, Biogas/Chemicals, Fertilizers/Composting and other feeding companies.

Having a look at the main value chain for the Aquaculture sector, iFishIENCi products' business enablers can be interconnected through different phases along the value chain of operations. While Individual Fish Farmers and Technology Developers will remain in first stages of the value chain of activities (*Inbound and Outbound logistics*, and *Operations*), both Policymakers / Investors and Feeding Companies will stay at post-commercialization phases (*Marketing & Sales*).

With the goal of embracing circularity, a remarkable opportunity emerges for collaborative partnerships between technology providers and vertically integrated aquaculture farmers. Farmers owning full control of operations throughout the value chain might have a deeper knowledge on how the technology could be adapted to their current in-house operations. Technology providers must engage with farmers in the process of offering a product that smoothly integrates to the farm characteristics as well as the institutional and economic factors affecting their business strategy. The partnership must allow fish farmers to revalorize waste throughout all stages so feeding companies can buy potential buy-products. Finally, investors interested in the potential results of the technology may engage adding capital for developing a more cutting-edge version of the existing product. This agreement could eventually reduce the risk of technology adoption for both technology providers and end customers, while propitiating product scaling up in certain target markets.

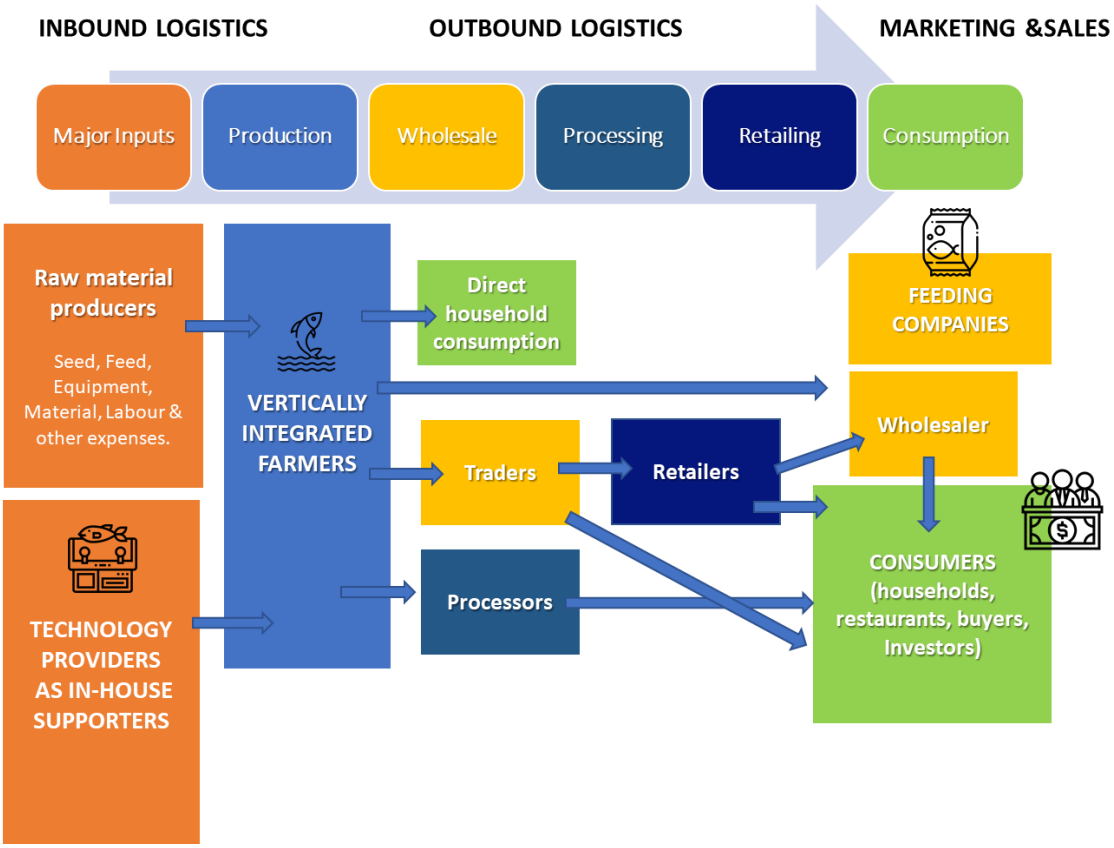


Figure 7. iFishIENCi product-approach in the value chain

4 Identification of Barriers and Challenges

An identification of barriers as well as challenges for the main iFishIENCi products can provide information about secondary business enablers who could facilitate a successful product-market fit in later stages of the value chain. During the product-based approach, a set of main barriers for each of the products has been identified and will serve as preliminary analysis (Table 4).

Table 4. Main barriers identified for the adoption of iFishIENCi products by business enablers.

Key Group	Barriers/Challenges
Fish farmers	Higher investment costs to incur due to the novelty of the technology.
	Lack of knowledge on how to cooperate with data experts for further developments on the product.
	Required educated staff capable for continuous training (need for new organizational competences).
	Requirement if high internet speed.
	Need of implementing KPIs aligned with business strategy so the risk to less technical groups can be reduced (risks associated to ignorance about performance optimization, predictive maintenance, and manufacturing).
Technology Providers	Need time to prove the concept with heterogenous samples (species).
	Product must be adapted to different species for dissemination.
	The product/technology must be adapted for different in-house aquaculture systems.
	A secure, smooth monetization model must be fixed for each technology provider to establish strong partnerships with fish farmers.
Feeding companies	Adoption of specific technologies (e.g., recycling technologies) and compatibility with fish farmers for the adoption of circular products and systems, maintaining the same quality level.
	Lack of supply network support due to customer behaviour rigidity in old practices
	Price of commercial nutrients is not always competitive (need to lower production costs)
Investors/Policymakers	Lack of information symmetry and knowledge on the pilot plant/technical risks in aquaculture, to translate them into economic risks, so they can provide long-term investments
	Misaligned incentives
	Due to more complex practices, need of more costly management and planning processes

As shown in table 4, one of the main barriers lies in the lack of technical knowledge and improvements these technologies could eventually have in fish farmers' operations. The more information and awareness on the product performance by fish farmers, and its results according to performance and resource optimization (materials and methods used, production process and volumes, predictive analysis results, maintenance) the lower the risks levels for the rest of business enablers along value

chain (technology providers, feeding companies and investors/policymakers). This also implies fish farmers' willingness to adapt current technical knowledge and expertise to a business strategy which can be understandable for all business players, needing to elaborate KPIs in different stages of Inbound/Outbound logistics and Operations. For instance, at manufacturing stage, the fish farmer may want to track the reduction of waste to landfill, whereas in logistics other KPIs such as reduction of number of components ordered, shipped, stored or the extension of product-life cycle will be monitored. Later, KPIs monitoring the effectiveness of maintenance and maximization of resource recovery will have to be overlooked and adapted according to the farm characteristics.

Primary information sources on the barriers for the adoption of the iFishIENCi products were introduced in 3.2.1.1 Business Enablers Primary Information Analysis (Adoption Main Barriers).

Considering iFishIENCi products innovation, the main two technologies corresponding to the Aquaculture 4.0 revolution will define different KPIs associated to their circular nature (Ellen McArthur, 2021):

- *Software for process optimization*. Sophisticated algorithms to control process parameters in real-time, balance quantity and quality of raw materials. KPIs associated:
  - Process productivity improvement
  - Reduction in consumption and waste.
- *Predictive maintenance*. Evaluation of actual condition of assets, failures and remaining life-time estimation, downtime reduction, productivity, and product quality improvement. KPIs associated:
  - Extension of asset life, acting only when needed, replacing only faulty components at the end of their life.

These KPIs will later be defined for the specific business models in next version of the iFishIENCi exploitation plan. A circular business model will be drawn to provide business enablers the tools to overcome current challenges the adoption of iFishIENCi products implies.

As of M30, the KPIs linked to the definition of circular business models within the frame of iFishIENCi are directly related to those already defined in WP4. These KPIs relate to the contributions to circularity main products to exploit expect to make in the future:

- *Improvement of social acceptability of fish farming.* Degree of perceived environmental impact by business enablers.
- *Increment of standardization of farms.* Degree of standardization of technologies and standards, adoption of processes and/or operational structure, bridging the gap between large commercial farms and farms of subsistence.
- *Reduction of labour costs for livestock monitoring.* Ability to reduce stress of livestock through the adoption and integration of technology, reducing human effort.

Following these considerations, the iFishIENCi consortium has also summarized future potential applications, derived from the implementation of iFishIENCi products into the targeted customers and thank to an efficient engagement of all business enablers along the value chain. The future challenges are associated to each products' performance (Table 5-8).

Table 5. Fish-Talk-To-Me: Expected application and impacts to circularity.

Product	Future application	Contribution to Circularity
Fish-Talk-To-Me	Aquaculture in **RAS systems** (fresh or salt water) Aquaculture in **open systems** (open cage equipped with RAS system) After the project, this system will be **adapted for any kinds of aquaculture farms**. **Real-time, remote automatic monitoring of fish behaviour in RAS and offshore/open sea** (high seas environment) aquaculture installations	Improvement of fish behaviour/welfare and reduction of fish losses and fish diseases; steps towards precision aquaculture. Reduce of drug treatments (antibiotics and others). Avoid and reduce over-feeding (costs associated to feeding and environmental impacts). Decrease fish waste. Improve social acceptability of fish farming. Increase the standardization of farms. Decrease cost of labour for livestock monitoring.

Table 6. i-BOSS: Expected application and impacts to circularity.

Product	Future application	Contribution to circularity
i-BOSS	**Integration of FishMet in Advanced Decision Support Systems** to be used in Aquaculture. Creation of **E-Labs.**	Improvement of fish behaviour/welfare and reduction of fish losses and fish diseases; steps towards precision aquaculture. Reduce of drug treatments (antibiotics and others). Avoid and reduce over-feeding (costs associated to feeding and environmental impacts). Decrease fish waste. Improve social acceptability of fish farming. Increase the standardization of farms. Decrease cost of labour for livestock monitoring.

Table 7. SMART RAS: Expected application and impacts to circularity.

Product	Future application	Contribution to circularity
SMART RAS	**Experimental RAS** aquaculture units. **Commercial RAS** products **Cloud-based connection** of farms and factories,	**Lower resource used** because of: Reduced energy use due to more efficient RAS management. Reduced water use and discharge because of more efficient water treatment. Reduced feed waste by optimising feeding regimes by using smart feeding system.

Table 8. Waste2Value: Expected application and impacts to circularity.

Product	Future application	Contribution to Circularity
Waste2Value	**Substrates for algae**: The knowledge about the reuse of dirty water as algae production can be applied to different algae strains. **Nutrients for algae and yeast**. The technology to solubilise nutrients from waste from the production of ingredients and sludge could also find applications in other sectors such as nutrients for agriculture	This technology will demonstrate potential valorisation routes to aquaculture waste streams towards zero waste strategy. Reduction of production losses and costs. Valorisation of low-quality biomass. Decrease energy and transport costs. Contribution to Zero waste strategy.

Amore descriptive roadmap on Comprehensive Analysis of Business Enablers, the definition of the circular-based business models, and the exploitation and the definition of commercialization roadmap for products has been disclosed (Figure 4) and divided into three steps and aiming to find a strong link between WP5 (Exploitation and Replicability) and WP6 (RRI, Dissemination and Capacity Building).

Step 1 is focused on the validation of key stakeholder groups throughout the value chain, to understand current needs and challenges when adoption aquaculture technologies. There are several actions involved:

- **Survey 1 Distribution ("Influencers", business enablers influencing aquaculture).** During D5.1, Section 2.3 "Identification and Prioritization of Barriers", it was defined two different surveys would be produced to gather valuable inputs for identifying business enablers and current challenges encountered by each of them. In this deliverable, Survey 1 (directed to "influencers") has been drawn and can be found in the Annex: Brief Stakeholders' survey. Survey 1 aims to verify the main stakeholders influencing and impacting on iFishIENCi's products' value chain of operations. Launch date was November 2022.
- **Product-based workshops.** These workshops were organized by the Steering Committee and led by Product Managers. They aim was to raise questions between Advisory Board members towards the marketability and engagement potential of the four main products of iFishIENCi. 1:1 pitching meetings have been held in order to prepare these workshops, involving product managers, WP6 and WP5 leaders, and active contributors to the marketability of products. 1:1 pitching meetings were held on May 2021.
- **Stakeholders Interviews.** Between Step 1 and Step 2, several stakeholder engagement actions took place according to WP6 Stakeholder Engagement Methodology (Aquaculture sector, End-consumers and Policymakers), which reflected on this study in order to gather the stakeholder lists present in D6.4, D6.6 and D6.8. During this stage several focus groups were organized in the framework of WP4, task 4.1. Additionally, the SC will gather the key topics raised by AB members, several interviews will be organized to key stakeholders, in order to start building Step 2: Definition of individual circular-based business models for the products.

Additionally, as part of Step 1, it can also be advanced that several focus groups have been taken place as part of Task 5.2.2.1 Stakeholder Engagement. One of the focus groups organized by TTZ in the frame of Task T4.1, led by Product Managers' inputs involved three scientific organisations and one private organisation, UiB also organised several focus groups with tech-users in Norway.

According to the focus groups results, one of the cornerstones for improving a higher degree of technology adoption and sustainability within Aquaculture was to increase awareness in the private investment field (Investors), so they can provide incentives to SMEs. Incentives coming from public regulations were also highlighted.

Different topics were raised on this focus groups, concerning aspects such as circularity, technology and sustainability implications within the respondents' fields of actions:

- *What is your definition of sustainability that you and your company use?*
- *What does digitalisation to you in your company?*
- *How can data sharing, and digital technology help you achieve sustainability goals in your company?*
- *What positive or negative issues do you think could arise in increasing technology in aquaculture?*
- *How important is it for you that aquaculture data is anonymous, but shared among the industry? Do you think a connected European aquaculture industry would lead to better aquaculture products?*

These results will be displayed in more detail in next deliverables within WP4 and WP6, and 5.3 had considered such results into this last version's analysis. Additionally, the questions raised by AB members within the product-based workshops will also be the base of the last version of the Exploitation Plan D5.6.

Step 2 is focused on the definition of circular-based business models, having gathered insights from main external stakeholders, AB members and iFishIENCi partners, it will be fed by the results of this deliverable in order to support the definitive exploitation strategy . It comprises two main actions:

- **Survey 2 ("End Users")** will be produced according to previous results gathered from Survey 1 and product-based workshops and interviews. Survey 2 will be directed to End Users of the different iFishIENCi's products, considering their value proposition, the targeted business enablers, as well as their competitive landscape.
- **Internal Trainings on products (in-project) to communicate target audiences.** This will be led by WP6 leaders according to the stakeholder engagement methodology but will also involve WP5 contribution. The aim is to increase awareness and provide the base to build business models that can be already tested by M48.

Step 3 is considered as a final step to start validating the methodology and draft a first commercialization plan (geographically focus) in order to validate the business models defined. A ready-to-market strategy is expected to be defined within the latest version of the Exploitation Plan. The roadmap will involve product managers and main IP owners of the technology, an aspect that will be defined in T5.5 IPR and Innovation Management (led by NORCE).

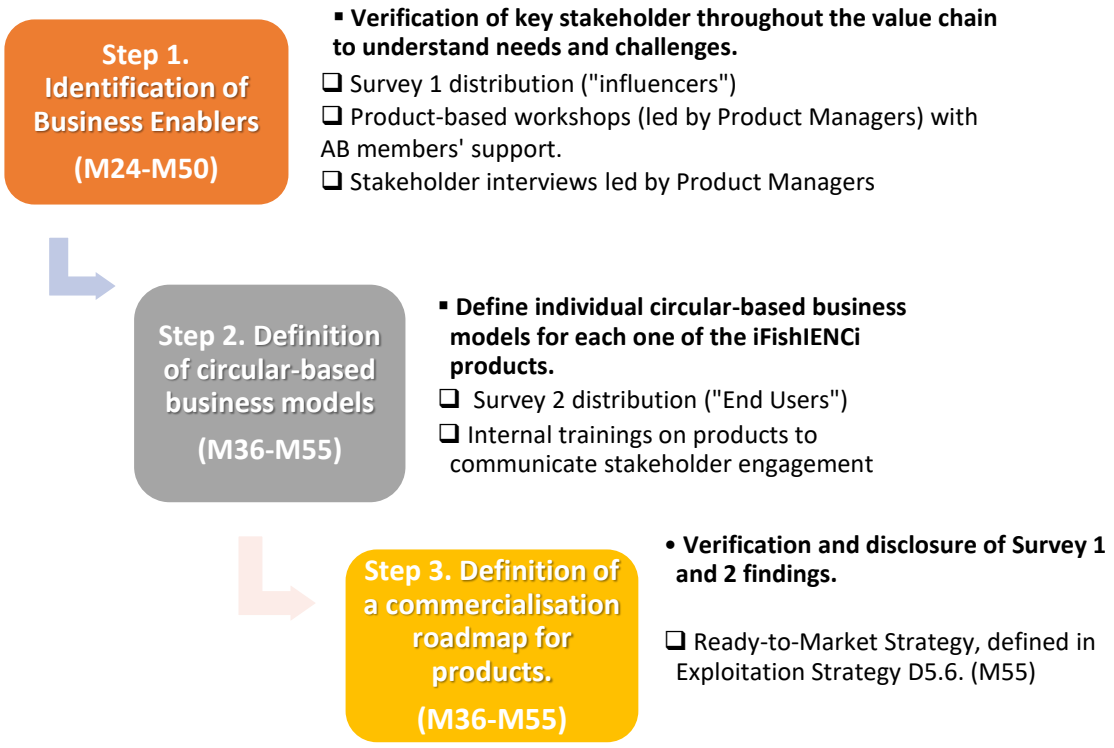


Figure 8. Roadmap to Activities related to Comprehensive Analysis of Business Enablers and Commercialisation for products (M24-M55)

5 Competitive Landscape

The main products of the iFIshIENCi project are positioned to compete in submarkets within both the Traditional and Precision Aquaculture sectors. These submarkets encompass a range of areas, including fish tagging technology, feeding technology, and the market for Aquaculture monitoring and control systems. By targeting these specific segments, the iFIshIENCi project aims to address the diverse needs and challenges present in both the traditional aquaculture practices and the emerging field of precision aquaculture.The products aim to serve as intermediaries for fish farmers to smoothly transition to more digitized, circular business models within their target markets of action.

The degree of competitiveness can be preliminary conditioned by three main factors:

- *Target Market conditions*. Although wanting to target a specific market, having a centralized feeding system is often the breaking point towards a more industrialized, accepting industry for new analytics companies to apply precision aquaculture. In developing countries, the ecosystem still confronts barriers for implementation given the decentralization of feeding systems and low-tech infrastructure, where the adaption of sensors is a big issue. Therefore, these aspects must be resolved and considered prior to roll out of a specific technology. Technologies adoption needing high-interconnected, sharing platforms may also confront problems due to low internet speed in certain geographical areas where target markets are located.

- *Underlying business model.* In the Figure shown below, direct, and indirect competition has been defined according to the underlying circular business model the iFishIENCi products aim to be fell into. According to the Accenture model on Circular Business Models (Accenture, 2015), there are five differentiated business model approaches on the specific solution can be characterized by and operate under a market: *Circular Supplies, Resource Recovery, Product-Life Extension, Sharing Platform and Product-As-A-Service*. Under the iFishIENCi project, products nature can be primarily based on Resource Recovery and PaaS approaches, having specific barriers and challenges attached to those. The competitive landscape will be further defined attending to these approaches, and it is not discarded to explore additional business enablers playing under the other business models (Sharing Platform players, Circular Suppliers).

- *Technical aspects on technology trials, production performance*. According to the results on technology trials in different species, production volumes, cage type, … the competitive value of the different iFishIENCi products may change. For instance, the RAS production of market size fish can be competitive with cage and flow-through productions because: Lower risks of fish losses during the final stages of the production due to improved monitoring and management, reduced production costs due to better Feed Conversion Ratio (FCR) because of applying smart feeding.

These factors will be later disclosed in more detailed, attending to the trials results and the target market identification. The following figure presents in a broader scope the competitive framework where iFishIENCi products lie in, where the degree of relevance goes from bottom to top.

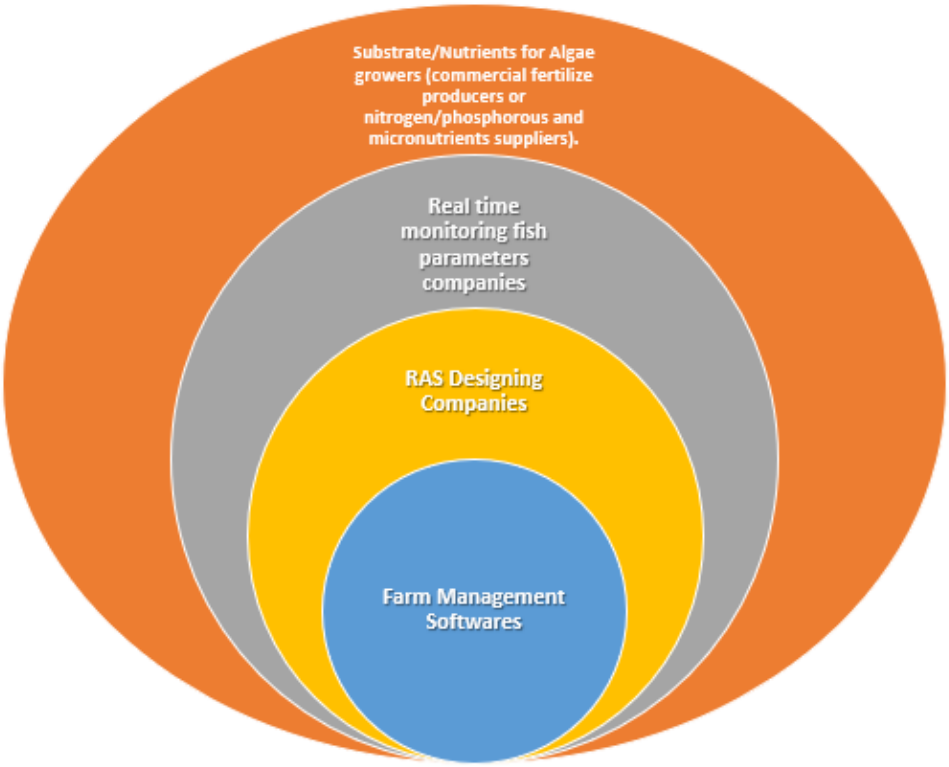


Figure 9. Main Competitive Landscape of iFishIENCi products.

An updated list of direct competitors has been drawn to set the basis for the design of a competitive value mapping in the final version of the Exploitation Plan (D5.6).

Table 9. Updated List of Competitors

Competitor type	Competitors' list
Software-based solutions for Real Time Monitoring Fish Parameter	• **Star-oddi** (based in Iceland, presence worldwide). 30-year experienced company devoted in the development of application software-based loggers, focusing on underwater environments and subsea gear, aquatic animals, wildlife and laboratory animals and production quality control. High performance additional services include logger recalibration, battery replacement and data analysis. • **Thelma Biotel** (based in Norway, presence worldwide). 20-year experienced firm developing a wide range of acoustic telemetry products for use in research and monitoring for submerged environments. Amongst their main products are sensor-based receivers, transmitters, and software-based applications. They also include as a service hard-wired tags and data storage solutions for the evaluation of new sensors and measuring methods for meeting specialized needs. • **BlueGrove** (based in Norway). A multinational firm providing hardware and software solutions, consisting of three main products: CageEye (hydroacoustics and smart algorithms to measure fish behaviour), NorseAqua (fish farming equipment) and SeaLab (camera technology solutions to provide continuous monitoring on the fish). https://bluegrove.com/

	• **EFishery** (based in Indonesia). Firm founded in 2013, it is a IoT-based solutions company, mainly focused on improving automatic fish feeding management. https://www.efishery.com/home • **Aqua Spark** (based in the Netherlands). An aquaculture-based company devoted to act as platform for a global community of investors, integrating a portfolio of coming innovative products targeting high-tech. https://www.aqua-spark.nl/portfolio/ • Other EU projects working in aquaculture on precision farming, i.e. **Innofish**
Farm Management Integrated software-based solutions	• **AquaManager (based in Greece)**. Firm specialized in providing integrated fish farming software solutions, aiming to help farmers during the grow out, and hatchery, by means of data mining and monitoring. Other services include data loggers and integrated mobile apps. https://www.aqua-manager.com/fish-farming-software-in-a-nutshell/ • **AquaTracker** (based in Cyprus). It is a specialized cloud-based integrated software aiming to improve feeding, and real time control and traceability of farm operational activities. https://www.aquatracker.com/ • **ScaleAQ** (based in Norway). Multinational firm specialized in seabased and landbased software solutions, including as part of aquaculture services the integration of feeding barges, camera and feeding systems, or cages. With a wide range of software solutions, FeedStation and Mercatus Farmer offer high-performance solutions to farmers. https://scaleaq.com/software/ • **Akva Group** (presence worldwide). Multinational company specialized in providing software-based solutions for cage farming and land-based fish farming. The software is called FishTalk and is linked to a process control platform called AKVAconnect, able to control small fish farms to several large, interconnected locations. They do also have AI-based data analysis solutions. https://www.akvagroup.com/home • **InnovaSea** (based in US, Norway, Chile, and Canada). Multinational company specialized in Open Ocean Aquaculture Intelligence, providing cloud-based software focused on feed optimization, environmental real monitoring and aeration and oxygen control**.** https://www.innovasea.com/aquaculture-intelligence/cloud-based-software/
RAS Designing Companies	• **Billund Aquaculture** (based in US, Denmark, Norway, Chile, and Australia). Multinational company specialized in the designing of a RAS single solution, covering all stages from fish tanks to grading. https://www.billundaquaculture.com/ • **AquaMaof** (based in Israel). Multinational company specialized in the designing of a RAS single solution, called Minimal Liquid Discharge (MLD) technology, utilizing several water treatments patents and filtering techniques to cut water consumption. https://www.aquamaof.com/ • **Sterner As(based in Norway).** Sterner is today the largest Norwegian-owned water treatment company. The company supplies process components and complete water treatment systems to customers mainly in aquaculture, well boats, food industry and municipalities. Sterner has head office at Ski outside Oslo and branch offices in Porsgrunn, Bergen, Trondheim and at Leknes in Lofoten. https://www.sterneras.no/en/home/ • **Artec Aqua** (based in Norway). The firm delivers ready-made facilities for farming on land and supplies products and systems for both flow-through, and recycling plants. The Ålesund company supplies turnkey plants and has also developed a number of proprietary products for RAS plants. http://www.artec-aqua.com/ • **Krüger Kaldnes** (based in Norway). Krüger Kaldnes has for almost 20 years provided the aquaculture industry with solutions and technology for water

	treatment. Krüger Kaldnes, in collaboration with a contractor, delivers a concept for total delivery of land-based farms. Today, as part of the Veolia Group, they are established as a leading RAS supplier in the global market and are known for several proprietary water purification solutions. https://www.krugerkaldnes.no/en • **Clewer Aquaculture** (based in Finland). The firm establishes turnkey RAS plants, which specializes in water purification through the design and construction of RAS systems. The Finns have experience in farming both trout and salmon smolt, as well as crayfish from mainly Finland, Sweden, the Baltics and Russia. https://cleweraquaculture.com/ • **Landing Aquaculture** (based in the Netherlands) The small team of experts is specialized for research RAS systems. (https://www.landingaquaculture.com/) • **MAT- RAS** (based in Turkey) The company has its own water treatment equipment design and production facility in Turkey, but very active on the Norwegian market with its daughter company called MAT-KULING AS. (https://mat-ras.com/) • **AlphaAqua** (based in Denmark) was founded in 2017 by two well-esteemed Danish companies, each with long track records in the aqua industry. They were determined to gather the best and most innovative technicians, vets and biologists in the international aquaculture industry in order to design and build the next generation of RAS systems for the global market (https://www.alpha-aqua.com/)

The list of competitors will be refined according to their market positioning (type of player) and market share they cover in their market of activity. The competitive value mapping will be drawn attending to the categorization of the different players, as well as the projected market positioning the iFishIENCi products may adopt at market entry stage. The value proposition for the iFishIENCi products has been designed according to the current state of art of the market (Table 10).

Table 10. iFishIENCi Products' Value Proposition

Key Group	Current State of Art	Value Proposition
Fish-Talk-To-Me	Today, fish behaviour is controlled by fish farmers in an empirical way. There are some systems using camera or sensors for fish monitoring but not for large scale breeding. Most of the parameters from the fish (biological) need analysis directly on the fish, are time consuming and expensive. We do not have enough info to optimize the management of physiological and biological parameters in fish farming.	The solution aims to **improve information for decision support and control system based on real time biological information directly from the fish**. The fish-talk-to-me tool will bring **standardization** to fish control. This new technology aims to improve aquaculture productivity.
i-BOSS	To date, microbiological monitoring, are based on cultivation methods. Results are available (at best) after 24 hours, even though up to 72h (Pathogen prevention)	The solution aims to 1) **Maximize feed utilization and minimize environmental impacts through Smart Feeding**, optimizing the efficiency of the presentation of feed to the fish in relation to fish state, environmental conditions, and species to maximize growth and reduce feed

		loss, reducing response times to aberrations. 2) **Provide Management Control through continuous monitoring of fish behaviour, health and welfare and reduce response times to aberrations in all production system.**
SMART RAS	The RAS farms usually includes water quality monitoring and alarm systems, but the large amount of data generated by the sensors are not used for AI and machine learning to develop and control the processes of the whole production system. There is high need recently for RAS based production of market sized Atlantic salmon and other valuable marine and freshwater species.	The new online monitoring and control system will make this level of optimization possible. The improved water treatment methods and higher level of monitoring will **reduce the production risks in RAS units for two main market areas:** Experimental Smart RAS: The product will enable more precise and accurate research with more data. This can shorten the research period and time required for licensing. Operational costs also will be lower. Commercial Smart RAS: Significantly reduced risk of fish kills, better feeding management and disease control, reduced operational costs.
Waste2Value	Currently sludge and wastewater in some countries is used as a fertiliser or to produce biogas, but not regarded as valuable source of feed. Biogas and energy production from sludge, as well as fertilizer production are still under development and optimization. To use fish manure from aquaculture in agriculture also needs the development of policy and legal framework in the EU. Sludge-grown microalgae production as a feed ingredient was first investigated by Wong et al, 1996, but requires further analysis in terms of different species and sludge composition.	The research data and developed methodologies will provide base for further product and service development of the partner companies. The results also can facilitate the policy discussions to make the aquaculture sludge reusable directly in agriculture. The **valorisation of waste into nutrients for the production of algae and yeast allows to reduce waste** and consequently, reduce waste management costs. The new nutrient resource can be economically feasible with the growing fertiliser prices.

The content of this deliverable has been meticulously crafted by combining findings from both secondary research and primary sources. Primary information includes valuable insights gathered through direct feedback from internal information sources such as iFishIENCi consortium workshops, discussions, and expertise. Additionally, external stakeholders have contributed their perspectives, enriching the overall understanding and analysis presented in this document.

Survey ("Influencers") responses aimed to collect valuable feedback about business enablers, to better understand the needs, barriers and challenges set by iFishIENCi products before commercialization phase. The survey findings to added great value to the building of individual business models in the objective to adopt circularity.

6 Annexes

6.1 Product Management Sheet (M30)

Product-Market Fit: **Fish-Talk-To-Me**

Key Exploitable Result

KER Name	Fish-talk-to-me Biology 4.0
Lead partner	BIOCEANOR
Participating partners	ABT, NORCEUR, COV, OXY, HCMR, SZIU, LEI, NORCE-IRIS, GE
TRL	Current: Expected at the end: 7
Estimate Time to get the Results:	
Work Package/Task	WP1, T1.2

Section 1: Fish-Talk-To-Me throughout the project

1. KER/Product description (Please include principal characteristics/functions/how it works, etc)

2. Contribution to Development and responsible for exploitation: please indicate the contribution of each partner and how the ownership will be distributed among the partners.

Partner	Contribution (explain)	IPR prior to the project that are using to generate the KER	Who will be responsible to exploit this KER
BIO			
HCMR			
SZIU			
LEI			
NORCE-IRIS			

Partner	Contribution (explain)	IPR prior to the project that are using to generate the KER	Who will be responsible to exploit this KER
GE			
ABT			
NORCEUR			
COV			
OXY			

3. Fish-Talk-To-Me Current State of Art and Experiments.

4. Contribution to Impacts. How will this new technology/product (KER) contribute to increase sustainability?

Section 2: Fish-Talk-To-Me – Going to the Market

5. Value Proposition. What makes this new technology/product (KER) attractive to the potential markets/users? Key benefits or problems solved by this new technology/product? What it does better than existing technologies/products?

6. Pros and Cons. What is the strength/advantage and weakness/disadvantage of this new technology/product (KER) comparing to existing technologies/products?

Strength/Advantage (e.g. Uniqueness or innovativeness)	Weakness/Disadvantage

7. **Benefits for potential target customers and way to market**. Who are the target customers or users and how to sell it?

8. **Potential competitors**. What technology/product/company do you think will be the major competitors for this KER?

9. **Future commercial applications.** What are the different applications for this new technology/product (KER)?

10. **Target geographical markets**. What are the target markets (in terms of continents and countries) you plan to enter and commercialize your technology/product? Please indicate the specific countries and companies if you already have some idea in mind.

☐ Europe, countries:
☐ North America, countries:
☐ South America, countries:
☐ Asia, countries:
☐ Africa, countries:
☐ Australia/Oceania, countries:
☐ Other (please explain: In all countries that have aquaculture)
☐ No, I don't have any market in mind for the moment.
Please, specify WHY.

6.2 Stakeholders' survey

Stakeholder's survey

- Directed to: Business Enablers: **Fish farmers, Technology Providers, Feeding Companies and Policymakers/Investors** (other: fish farming software companies, RAS designing companies, Fish parameter monitoring companies, Algae Nutrient and Substrate growers, etc.).

Summary

Aquaculture 4.0 technologies have landed and are very likely to stay, aiming to play a major role within the implementation of new Circular Bioeconomy approaches. In this context, European **aquaculture** has been recently applying innovative and disruptive technologies to transform fishery management strategies. The so-called "4th industrial revolution" is projected to allow **a 15-20% increase in the sector by the year 2030**. In addition to the growth the revolution can provide, the benefits of Industry 4.0 include improved productivity, efficiency and reduced costs. Companies will be able to produce more, in less time, while allocating resources more effectively, due to a smooth adoption of interconnectivity through the Internet of Things (IoT), access to real-time data, and the introduction of cyber-physical systems. According to FAO data, the estimated production volume of fish from European aquaculture in 2028 will increase to approximately 1.4 million tons, needing more circular, digitized solutions to cover end user demand. (Bianchini & Pellegrini, 2019).

The **iFishIENCi project** is an EU-funded project conformed by multi-disciplinary professionals representing the whole value chain, that will deliver breakthrough innovations supporting sustainable aquaculture, based on enabling technologies and circular principles, thereby providing the European aquaculture industry with the competitive advantage and growth stimulation needed to be a mover in revolutionizing global efficiency in fish production and meet society's needs for food from the ocean.

The results of this survey will teach us what are the main challenges faced within the Aquaculture 4.0 market concerning usage experience and level of awareness, in order to identify barriers for implementation and key drivers to encourage adaptation of innovative technologies within their businesses. The insights gathered will help us to improve our concept and ultimately the whole value chain of the Aquaculture 4.0 market. (Included as pop-out for those not able to read the introduction).

Thank you very much!

Introduction

Identification of the Stakeholder profile and country:

A) For which countries could you provide feedback on the Aquaculture market?
   - Norway
   - Greece
   - Malta
   - Germany
   - Spain
   - *Other*

B) Which of the following stakeholders' categories describes best your organization best?
   One single question, only one choice allowed.
   - Research
   - Aquaculture farmer
   - Equipment manufacturer

- Technology products manufacturer (sensors, etc).
- Consultancy firm
- Maintenance and equipment manufacturer
- System vendor
- Investment institution

Survey

1) Do you have previous experience implementing aquaculture technologies within a project/or your in-house operations? If yes, would you be willing to include it again? If no, why?

   Yes/ No question
   + (OPEN gap to add comments)

2) Please specify the level of influence (1 Low-5 High) the described decision makers have when implementing aquaculture technology solutions in a specific project.
   (1 slider per each decision maker)

- Raw materials suppliers (seed, feed, equipment, material…)
- Technology providers (System vendors)
- Local Authorities
- Wholesale and retailers
- Fish farming players
- End consumer (households, restaurants, other buyers)
- Others

3) Considering sustainability as the main goal achieved when implementation innovative technologies in aquaculture, what are the main targets considered to be reached?
   Multiple answers allowed (MCQ)

- Feed and resource optimization
- Resource recovery
- Environmental certification standards
- Extension of product life cycle
- Organizational energy/product waste costs

4) What are the parameters you consider relevant to select the most suitable aquaculture technology products for your field/ markets of action?

- Quality of raw materials
- Integration with other RAS systems, in-house operational systems
- Costs (upfront investment, supply costs…)
- Scale of the project
- Return on Investment (ROI)
- Payback period
- Partners involved in the project (the specific technology provider)
- Other

5) Please rank the level of relevance (1 Low -5 High) of the aquaculture key market drivers in your markets of action (at country level).

- Zero energy and waste strategy directives
- Requested by certification schemes.
- Significant demand for aquaculture technology products in markets of action
- Financial incentives
- Environmental awareness
- Increasing of renewable technologies penetration by clients
- Increasing efficiency/ROI of by adopting new technologies

6) Regarding the regulatory framework in the markets of action (at country level), please indicate the most appropriate statement. One Single Question, only one choice allowed.

- Current regulations encourage/fit promotion of aquaculture technology products.
- European and National regulations are in conflict.
- Aquaculture-based regulations are totally independent from the regulatory landscape.
- Regulations limit aquaculture technologies application and therefore there is a need for new regulations to arise.
- Other: (enter text)

7) Regarding incentives on aquaculture technology adoption in your markets of action. Please indicate the most appropriate statement. One Single Question, only one choice allowed.

- The Aquaculture Technology market growth is independent from incentives.
- There is a need for new innovative incentives in the field of Aquaculture 4.0.
- Current incentives fit and promote Aquaculture technology market growth.
- National and European incentives to boost Aquaculture technologies adoption do not match.
- Other:

8) Please rank the level of importance/relevance (1 Low -5 High) of Aquaculture 4.0 applications in your field/markets of action:

- Industrial Aquaculture
- SME Enterprise aquaculture
- Small-scale Commercial aquaculture
- Subsistent aquaculture

9) Please rank the level of importance (1 Low -5 High) the benefits of Aquaculture 4.0 technologies have in your field/ areas of action:

- Improvement of fish behaviour/welfare
- Reduce of drug treatments.
- Reduction of fish waste.

- Optimization of other resources (reduction of feed waste, reduction of energy usage).
- Standardization of farms and increase in the social acceptability by farmers.
- Increase of awareness for investors to provide alternative funding schemes.

10) What are the challenges of Aquaculture technology adoption in your field/areas of action? Rank in terms of priority (1 Low – 5 High).

- Cost reduction (upfront investment costs are currently high)
- Lack of information symmetry and knowledge on the pilot plant/technical risks in aquaculture by non-technical groups to promote cooperation.
- Need of implementing KPIs aligned with business strategy so the risk to less technical groups can be reduced (risks associated to ignorance about performance optimization, predictive maintenance, and manufacturing).
- Product flexibility and adaptability to any type of farm
- Standardization across industry
- Regulations

11) Could you please explain what are the main challenges that have limited BIPV applications within your field/areas of action? And any suggestions in order to overcome them (Open Question).

- Challenges (OPEN)
- Suggestions (OPEN)

12) Do you consider familiar with Aquaculture's latest technology development and product offerings in the market?

Range: Very familiar (5), Not familiar (0)

13) What are the sources of information you usually make use of when getting informed about Aquaculture 4.0 latest news and updates?
Multiple Answers Allowed (MCQ):
Internet News Portal / Contacts from the sector / Associations / Consultancy firms/ Other (OPEN QUESTION "please specify")

14) Lastly, do you consider there is a need for education in Aquaculture 4.0 within your field/sector?

Yes/No Question.

If yes, what are the means you consider more efficient to address it?
Multiple answers allowed. (MCQ)

- Production and sponsoring of training materials in associations with high visibility.
- Keep raising awareness in conferences/events.
- Product demonstration in international fairs

- Other (OPEN QUESTION "please specify")

15) Please, make your recommendations on how Aquaculture technology adoption can be trained to increase the know-how within your field/markets of action:
OPEN QUESTION

Voluntary Question

16) According to the World Bank estimations, only the projected 2030's global demand will be covered if both data monitoring experts and fish farms engage in strong partnerships that can standardize and facilitate digital transformation of Small and Medium aquaculture players. Do you agree with this statement? Can you specify why?

— Strongly Agree/ Strongly disagrees

— + Open gap to add comments: "Specify why: ____ "

6.3 Brief Stakeholders' survey.

The Future of Aquaculture: The impact of industry 4.0 technologies worldwide (2023)

The so-called "4th industrial revolution" -Aquaculture 4.0 - is projected to enable a 15-20% increase in the aquaculture sector by the year 2030. In this context, European aquaculture has been recently applying innovative and disruptive technologies to transform fishery management strategies, with major impact on the implementation of new Circular Bioeconomy approaches. In addition to the expected impact on growth, the benefits of Aquaculture 4.0 include improved productivity, efficiency, and reduced costs.

By answering this survey, you will contribute in defining, integrating and scaling-up better solutions that aim to accelerate the blue growth economy. The approximate time of completion is 4 minutes. We thank you in advance!

OK

1. In what country do you work?

Other (please specify)

2. Which of the following stakeholders' categories describes your organization best?

- ◯ Research.
- ◯ Consulting firm.
- ◯ Aquaculture farmer.
- ◯ Maintenance and repair of equipment provider.
- ◯ Equipment manufacturer.
- ◯ System vendor.
- ◯ Technology products manufacturer and/or vendor (RAS, sensors, etc).
- ◯ Investment institution.
- ◯ Other (please specify).

3. Do you have previous experience implementing aquaculture technologies within a project/or your in-house operations?

- ◯ Yes and I will be willing to include it again.
- ◯ Yes and I will not be willing to include it again.
- ◯ No, I will be willing to consider it.
- ◯ No, I will not be willing to consider it.

4. What are your largest barriers to adopting new aquaculture technologies?

	Very low barrier	Low barrier	Neither low nor high barrier	High barrier	Very high barrier
Investment costs are high.	◯	◯	◯	◯	◯
Lack of information available.	◯	◯	◯	◯	◯
There may be technical risks of using them.	◯	◯	◯	◯	◯
I don't know how to assess their success (e.g. Performance indicators).	◯	◯	◯	◯	◯
I don't know if they are flexible and adaptable to my operations.	◯	◯	◯	◯	◯
There is no standardisation across the industry.	◯	◯	◯	◯	◯
Regulatory issues or restrictions.	◯	◯	◯	◯	◯
They are difficult to use/ there is no training available.	◯	◯	◯	◯	◯

5. What are the aquaculture challenges that you would like technology providers to prioritise solving?

	Very low priority	Low priority	Neither low nor high priority	High priority	Very high priority
Improving fish welfare.	○	○	○	○	○
Monitoring fish behaviour.	○	○	○	○	○
Reducing the need for pharmaceuticals use.	○	○	○	○	○
Reducing waste products (waste water, fish sludge).	○	○	○	○	○
Reducing overuse of resources (feed, energy, water, etc.).	○	○	○	○	○
Standardisation.	○	○	○	○	○
Improving consumer and investor awareness.	○	○	○	○	○
Increasing profitability.	○	○	○	○	○

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